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Frictioned Micromotion Input for Touch Sensitive Devices

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Background

Many mobile computing devices with touch sensitive surfaces (smart phones, tablets) have a "lock" feature to block unauthorized access. Typically this is accomplished by placing the device in a default "locked" state. When the user wishes to interact with the device, the user will perform an "unlock" action.

Let D be a device that supports a touch sensitive surface (TSS); *e.g.,* touch screen computers, tablets, smart phones, smart watches, and/or head-mountable devices with touchscreens. TSS components may be implemented using capacitive touchscreens. Typical TSS usage involves controlling the position and/or velocity of fingers (or soft-tip styluses). Then, when a user's finger contacts the TSS of device D, the contact is not at a single point, but a 2D contact region that covers multiple pixels of the TSS. The TSS clusters and averages the contact region to register discrete points along with pressure values estimated from areas of 2D contact regions.

Detailed Description

This disclosure describes an alternative TSS interaction mechanism: Change in finger-TSS interfaces caused by balancing applied force against static friction at the interfaces. This can be manifested by coordinating multiple joints of a finger to roll a fingertip over the TSS without specifically dragging, sliding, or moving the finger across the surface of the TSS. In other words, the force of friction between the fingertip (or stylus tip) and TSS keeps the tip in the same location, but the force of the hand causes the tip to deform against the TSS. This causes the finger-TSS interface to change shape. Let us designate this class of motions as “wiggles”. This mechanism is already applied for fine motions, e.g., moving a text edit caret. Soft-tip styluses can wiggle in a similar fashion. Wiggles lead to minute motions that are detectable by the TSS while being difficult to notice by onlookers.

Wiggles can be detected by software and hardware of device D. Wiggles can provide device D with direction information, analogous to a joystick, as well as some (low-resolution) magnitude information. For an unlocking application, initially a sequence of multiple wiggles (called a “wiggle path”) can be entered and stored at device D. Then device D can use the stored “registered wiggle path” to unlock the device (*i.e.,* like a password). Later, an “input wiggle path” can be entered and compared to the registered wiggle path. If the input wiggle path matches the registered wiggle path, device D can be unlocked; otherwise, no match is found and device D can remain locked.

Finger motions for creating wiggles can be entered discreetly, and wiggling does not require visual feedback. For instance, executing an input wiggle path can be performed while device D is out of sight, such as in one's pocket or purse, and this approach addresses efficiency and privacy issues. Richness and mutability properties can also be satisfied, since wiggle motions can have a high degree of freedom, and a user can change a registered wiggle path.

A registered wiggle path can be set and/or changed by pattern matching, i.e., a user can be asked to follow a registered wiggle path multiple times. To help a user learn how to enter (registered) wiggle paths, a "sandbox" can be provided by a display of device D to train a user by showing wiggle movements, thus allowing the user to set, test, and see a registered wiggle path. The sandbox can provide information to encourage associating wiggle motion with other activities; *e.g.,* a wiggle path can be based on writing or drawing a shape with one or more fingers. In such a usage, the user can be encouraged of think in terms of operating a joystick to trace out a path.

Device D can generate an internal "wiggle profile" for the user related to user-specific finger motions. To unlock device D, pattern recognition algorithms can be used, perhaps using the wiggle profile as an input, to ignore minor ambiguities between an input wiggle path compared to a registered wiggle path.

The wiggles can involve movement(s) in one or more directions that specify one or more directional operations. For example, the direction can be specified as relative or objective compass points; *e.g.,* N (North), S (South), E (East), W (West), NE (Northeast), SE (Southeast), SW (Southwest), NW (Northwest), NNE (North-Northeast), ENE (East-Northeast), ESE (East-Southeast), SSE (South-Southeast), SSW (South-Southwest), WSW (West Southwest), WNW (West-Northwest), and NNW (North-Northwest). Wiggles can be in “UP” and “DOWN” directions (not to be confused with N and S compass points) that can be detected by change of finger pressure (on a suitably sensitive device). For example, device D can detect a change of finger pressure over movement in an up and down direction over a finger contact region. In other embodiments, a change in finger contact regions can signal UP and DOWN motions; that is, device D can determine a change in the finger contact region where the finger had been but is no longer positioned.

Directional operations can be determined based on directions calculated from a central point associated with a finger; *e.g.,* an initial position of the finger, a centroid of positions reached by wiggles made by the finger, or a weighted average of positions reached by wiggles made by the finger; *e.g.,* windowed and/or exponentially weighted filter to track recent movements. Directional operations can be determined based on directions calculated from a non-central point associated with a finger as well; *e.g.,* direction from a last-reached position by the finger, or some other position. In this respect, the wiggle input can differ from joystick input, which has an absolute central point

Directional movements can be combined to make more complex operations. For example, a finger pressed in the “DOWN” direction can reduce pressure and move “UP”, where the reduction in pressure and “UP” direction can be classified as a “LIFT” operation. As another example, a composite operation such as a “TWIRL” operation can involve detection of wiggles that rapidly visit successive compass points in a clockwise or counterclockwise order.

In some embodiments, the first directional movement can be designated as a northward directional movement. Designation of the direction of the first movement as always being northward can make the unlock feature orientation-agnostic, and reduce or eliminate a need for visual feedback. In particular for these embodiments, tactile feedback (e.g., vibration) can indicate successful unlock. Tactile feedback can provide feedback even while device D is unlocked and hidden from view, such as in a user’s pocket or purse. In some embodiments, directional movements can be determined with respect to an external standard location or direction; *e.g.,* standard compass bearings or a fixed orientation with respect to a housing of device D.

In other embodiments, timing can be exploited to capture more information; *e.g.,* to determine when a wiggle path or sequence of wiggles, has ended; to introduce a "DELAY" operation into the wiggle path.

In even other embodiments, a fallback method for unlocking the device can involve explicitly typing or drawing a registered pattern should the user have trouble entering a wiggle path that sufficiently matches the registered wiggle path. Other fallback methods can include more elaborate password inputs, or remote resets.

In still other embodiments, wiggles can involve multiple fingers and/or multi-touch for entering registered wiggle paths and input wiggle paths. An example of a multiple finger wiggle can involve a user holding device D with both hands, and using both thumbs and/or other finger(s) to compose different wiggles. This can be distinguished from traditional "pinch" or "rotate" gestures, as the emphasis would be on applying force to cause minute changes in conformation in the physical interface between the contacting fingers and the TSS. Thus, instead of making "pinching" or "expanding" finger gestures, respective "SQUEEZE" or "STRETCH" multi-finger wiggles can be performed. Note that these can be directional or non-directional. Similarly, instead of a traditional rotate gesture, a corresponding "TORQUE" multi-finger wiggle can be performed, where a multi-finger TORQUE is not to be confused with single-finger "TWIRL". Multiple fingers can wiggle in the same direction. Using three or more fingers gives rise to more complex motions. Additionally, other operations such as "SQUEEZE", "STRETCH", and "TORQUE" may be executed with three or move fingers.

In some embodiments, wiggle motions can be detected over the entire TSS to maximize coverage. In other embodiments, different areas on the TSS can be designated for different purposes. In particular, the phone unlocking feature one might only specify one portion of the TSS (such as the center of screen) as an active area, while other areas of the TSS (such as different border regions) can be assigned to different purposes, e.g., activate camera, or show password input dialog. In gaming and other application scenarios, different wiggle areas on the TSS can be designated for (different) wiggle inputs. For example, a bottom left wiggle area and a bottom right wiggle area of a TSS can be assigned. In this case two joystick-like inputs can be obtained via the two assigned wiggle areas. For each wiggle action, the reference center point can adapt to initial (and historic) finger/thumb placement, rather than a fixed location on the screen.

Other sensors of device D can be used to detect and/or enhance wiggles via sensor fusion; e.g., sensors such as gyroscopes, accelerometers, microphones, and cameras. Gyroscope readings can be correlated with mobile phone tilting if one is attempting the single-handed wiggle maneuver. Microphone(s) can capture wiggle-related sound data, such as tap sounds, to (help) determine finger locations. Camera(s) can capture wiggle motions. Then, optical flow techniques and/or clustering can be used to determine wiggle paths. Also, skin tones captured in images can improve captured wiggle-related signals from images.

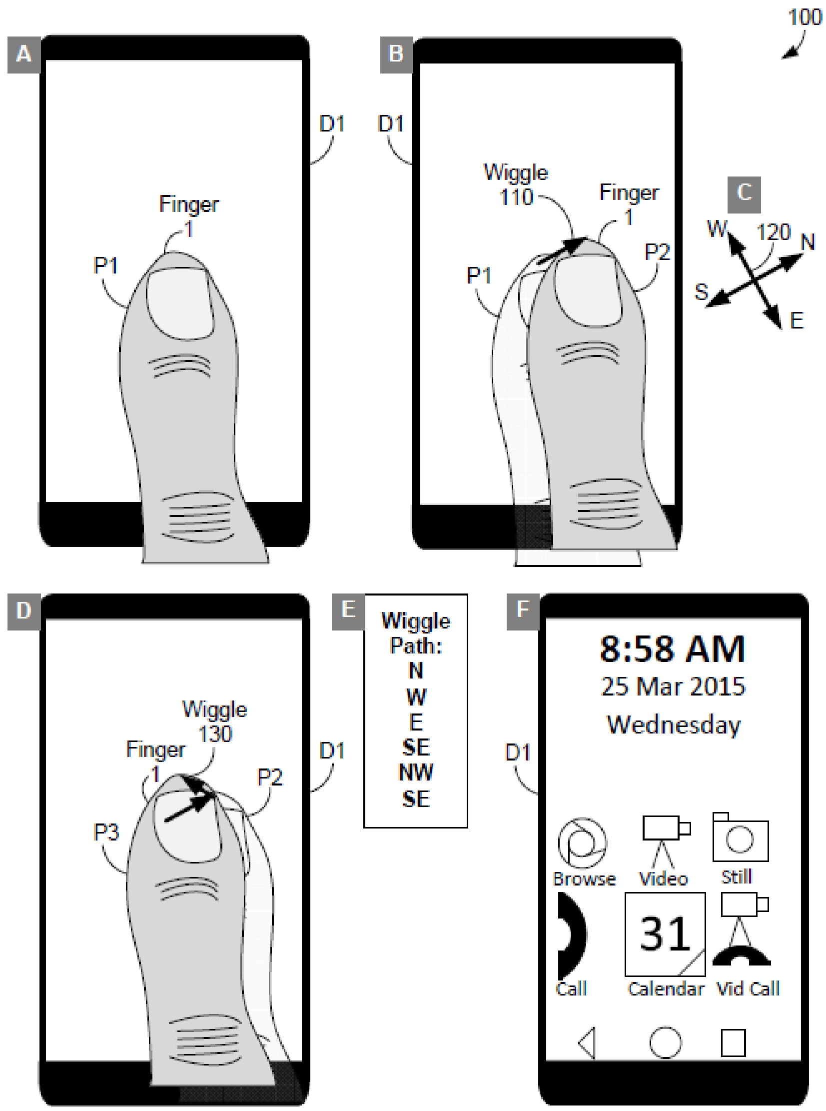

FIG. 1

FIG. 1 shows example scenario 100 of using Finger 1 to generate a wiggle path and unlock a mobile device D1 with a touch screen as the TSS. Scenario 100 starts at location “A” at upper left of FIG. 1 where Finger 1 is placed at initial position P1 on the touch screen of device D1. In scenario 100, device D1 includes software and hardware for detecting wiggle paths from one or more users, including a user U1 who has registered a wiggle path for unlocking device D1.

Scenario 100 continues at location “B” at upper center of FIG. 1 where U1’s Finger 1 has moved from initial position P1 shown using a relatively-light color of Finger 1 to second position P2 shown using a relatively-dark color of Finger 1 to generate wiggle 110. Movements of fingers in scenarios 100 and 200 are shown as relatively large moments for illustration purposes – in some embodiments, device D1 of scenario 100 (and device D2 of scenario 200) can detect smaller movements of Finger 1 from P1 to P2, and so wiggles, such as wiggle 110, can be just a change in pressure or orientation of the finger, which are smaller in these embodiments indicated in the Figures.

Location “C” at upper right of FIG. 1 shows an example set of compass headings 120 based on the direction of wiggle 110. As mentioned above, the first directional movement of a wiggle path can be designated as a northward directional movement. In scenario 100, the first directional movement is wiggle 110, and so the set of compass headings 120 show north (“N”) being in the same direction as wiggle 110. Location “D” at lower left of FIG. 1 shows Finger 1 has moved from second position P2 shown using a relatively-light color of Finger 1 to third position P3 shown using a relatively-dark color of Finger 1 to generate wiggle 130. As wiggle 110 is in a northward direction, by designation, wiggle 130 is in a westward direction.

Scenario 100 continues with Finger 1 generating wiggles for an input wiggle path shown at location “E” at lower center of FIG. 1. The input wiggle path includes initial wiggle, wiggle 110, in a northward direction shown using a “N” designation of the wiggle path, a second wiggle (wiggle 130) in a westward direction as shown using a “W” designation of the wiggle path, and subsequent wiggles in eastward “E”, south-eastward

“SE”, north-westward “NW”, and south-eastward “SE” directions, leading to the indicated wiggle path of “N W E SE NW SE”. In scenario 100, user U1 has previously registered a registered wiggle path of “N W E SE NW SE”. Scenario 100 continues with device D1 determining that the input wiggle path matches the registered wiggle path, and so device D1 is to be unlocked for use by user U1 as shown at Position “F” at lower right of FIG.1. After device D1 is unlocked, scenario 100 can end.

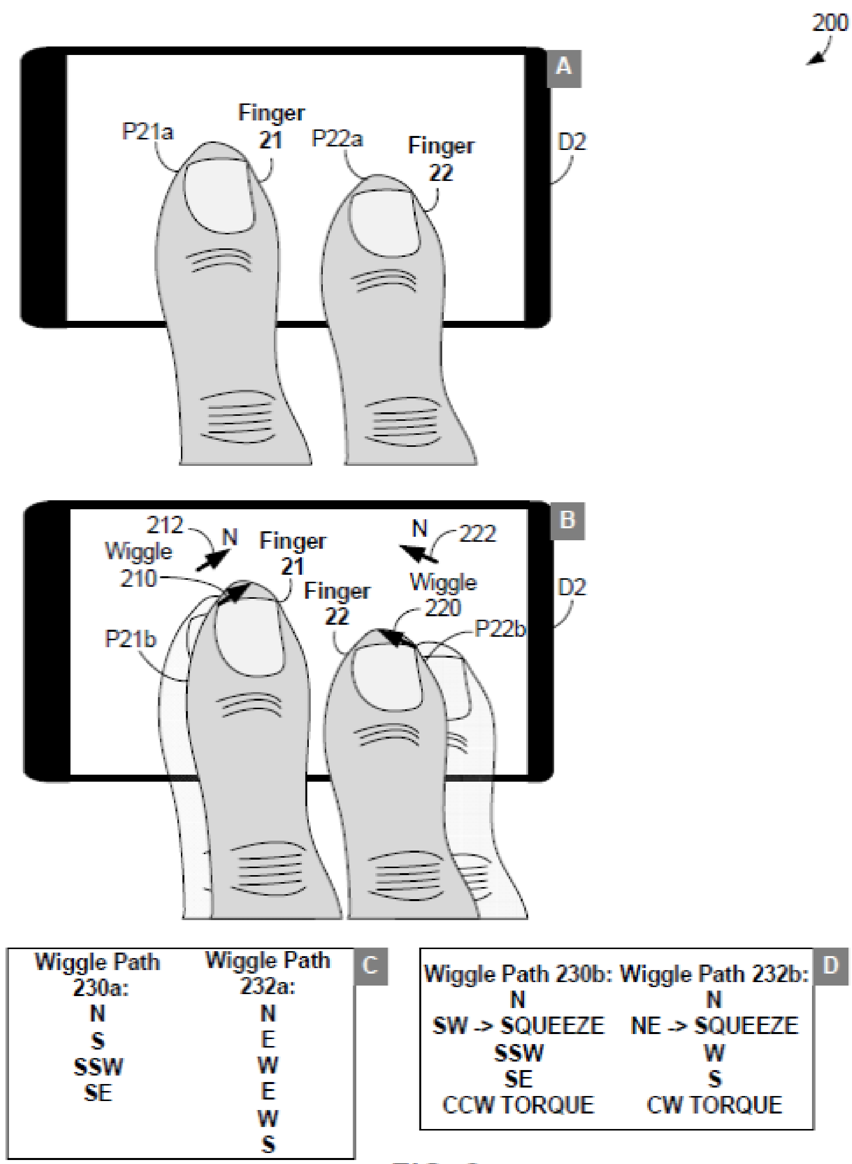

FIG. 2

FIG. 2 shows example scenario 200 of using multiple fingers Finger 21, Finger 22 to generate wiggle paths on a mobile device D2. Scenario 200 starts at location “A” at top of FIG. 2 where Finger 21 is placed at initial position P21a and Finger 22 is placed at initial position P22a on a touchscreen of device D2. In scenario 200, device D2 includes software and hardware for detecting wiggle paths from one or more users, including a user U2 whose fingers include Fingers 21 and 22 and who has registered multiple wiggle paths for unlocking device D2.

Scenario 200 continues at location “B” at center of FIG. 2 where Finger 21 has moved from initial position P21a shown using a relatively-light color of Finger 21 to second position P21b shown using a relatively-dark color of Finger 21 to generate wiggle 210. Finger 22 has also moved from initial position P22a shown using a relatively-light color of Finger 21 to second position P22b shown using a relatively-dark color of Finger 22 to generate wiggle 220. As explained previously with respect to FIG. 1, the wiggle motions have been exaggerated for illustration purposes and the fingers may not actually seem to move locations. Instead, the pressure change caused by contracting different muscles of the hand causes the individual touch pixels to register contact differently.

Position “B” of FIG. 2 also shows an example north compass heading 212 for Finger 21 based on the direction of wiggle 210 and a separate north compass heading 222 for Finger 22 based on the direction of wiggle 220. As mentioned above, the first directional movement of a wiggle path can be designated as a northward directional movement. In scenario 200, the first directional movement is wiggle 110, and so compass heading 212 shows north (“N”) being in the same direction as wiggle 110. As such, “North” for Finger 21 differs from “North” for Finger 22.

Scenario 200 continues at location “C” at lower left of FIG. 2 where Fingers 21 and 22 have each generated respective input wiggle paths 230a, 232a. Wiggle paths by different fingers can differ in direction(s) and number of wiggles. For example, wiggle path 230a is “N S SSW SE” indicating northward, southward, south-southwestward, and south-eastward motions of Finger 21, and Wiggle path 232a is “N E W E W S” indicating northward, eastward, westward, eastward, westward, and southward motions of Finger 22. In some embodiments, device D2 can be unlocked when both wiggle path 230a and 232a match two respective registered wiggle paths. In these embodiments, a registered wiggle path can be associated with a finger providing an input wiggle path; *e.g.,* a registered wiggle path “R1” can be associated with an input wiggle path from a leftmost (or otherwise designated) finger, while another registered wiggle path “R2” can be associated with an input wiggle path from a rightmost (or otherwise designated) finger. That is, in scenario 200, if R1 was associated with a leftmost finger, then R1 would be compared to the input wiggle path 230a from Finger 21, R2 would be compared to the input wiggle path 232a from Finger 22, and device D2 would be unlocked if both R1 and R2 matched their respective input wiggle paths.

In other embodiments, a registered wiggle path may not be associated with a finger providing an input wiggle path; that is R1 would be compared to both input wiggle path 230a from Finger 21 and, if necessary, input wiggle path 232a. If R1 matched either input wiggle path, then R2 could be compared with the other, non-matched input wiggle path to determine if device D2 should be unlocked. If R1 did not match either input wiggle path, then device D2 can remain locked.

Scenario 200 continues at location “D” at lower right of FIG. 2 where Fingers 21 and 22 have each generated respective input wiggle paths 230b, 232b. Input wiggle paths 230b, 232b include operations that include directional operations, TORQUE operations that indicates wiggles along a path that rotates clockwise (CW) or counterclockwise (CCW), and multi-finger wiggles as discussed above. In particular, FIG. 2 shows that wiggle path 230b is “N SW->SQUEEZE SSW SE CCW TORQUE” indicating that a southwestward motion was replaced by a SQUEEZE multi-finger wiggle operation and entry of a counter-clockwise TORQUE operation. FIG. 2 also shows wiggle path 232b is “N NE->SQUEEZE W S CW TORQUE” indicating that northeastward motion replaced by a SQUEEZE multi-finger wiggle operation and entry of a clockwise TORQUE operation. Wiggle paths 230b and 232b can be matched with registered wiggle paths to unlock device D2 as discussed above in the context of location “C” of scenario 200, and scenario 200 can end.

Single-finger or multi-finger wiggle movements can be combined with standard single-touch or multi-touch tap, hold, slide, or pinch movements to develop touch-gestures with an additional layer of complexity and discreetness for unlocking and other gesture-based touch controls for electronic devices.

ABSTRACT

Techniques are provided for securing devices using wiggles, which can include small finger motions made on a touch screen associated with a device. The wiggles can be made by one or multiple fingers and can be made without lifting a finger from the touch screen or sliding the finger along the touch screen, which makes wiggles difficult to observe and therefore difficult to reproduce by another person. Wiggles can include directional motions, rotational motions, and multi-touch motions. For applications in device unlocking, a user can register a “wiggle path” and then later execute an input wiggle path discreetly. The device can compare the input wiggle path against the registered wiggle path. If a match is found, the device can grant access to the user.